UNITED STATES DEPARTMENT OF AGRICULTURE

FOREST SERVICE
REGION ONE

ENGINEERING REPORT

Water Quality of Groundwater
Near the West Yellowstone Sanitary Landfill

Harry Kringler - Sanitary Engineer

Gallatin National Forest

November 1977

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Acknowledgments

The following staff members of the Soil Conservation Service State Office in Bozeman have been instrumental in the location and installation of the groundwater monitoring wells and providing valuable technical assistance:

David Jones, Sanitary Engineer
Sherman Sollid, Geologist
Harry Brence, Drill Operator

Abbreviations

BOD - Biochemical Oxygen Demand

COD - Chemical Oxygen Demand

EPA - Environmental Protection Agency

mg/l - milligrams per liter, equivalent to parts per million in water

NLES - National Lake Eutrophication Study

SDWA - Safe Drinking Water Act

TDS - Total Dissolved Solids

umhos/cm - micromhos per centimeter

< - Less than

Definitions

Leachate - leachate is formed by water percolating down through the buried refuse cells and is contaminated by substance dissolved from the refuse.

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INTRODUCTION

This report is a summary of water quality data of water samples taken from groundwater monitoring wells near the West Yellowstone Sanitary Landfill in 1976 and 1977. The summary is based on a limited number of samples but the large increase in dissolved solids in groundwater wells downstream from the landfill indicates that leachate is reaching the groundwater. It is recommended that this summary be made available to appropriate regulatory agencies to see if the landfill site is in violation of water pollution regulations. It would also be useful to have the appropriate agencies review the data and comment on a future course of action at the site (need for additional monitoring, modification of operating plan, etc.)

HISTORY

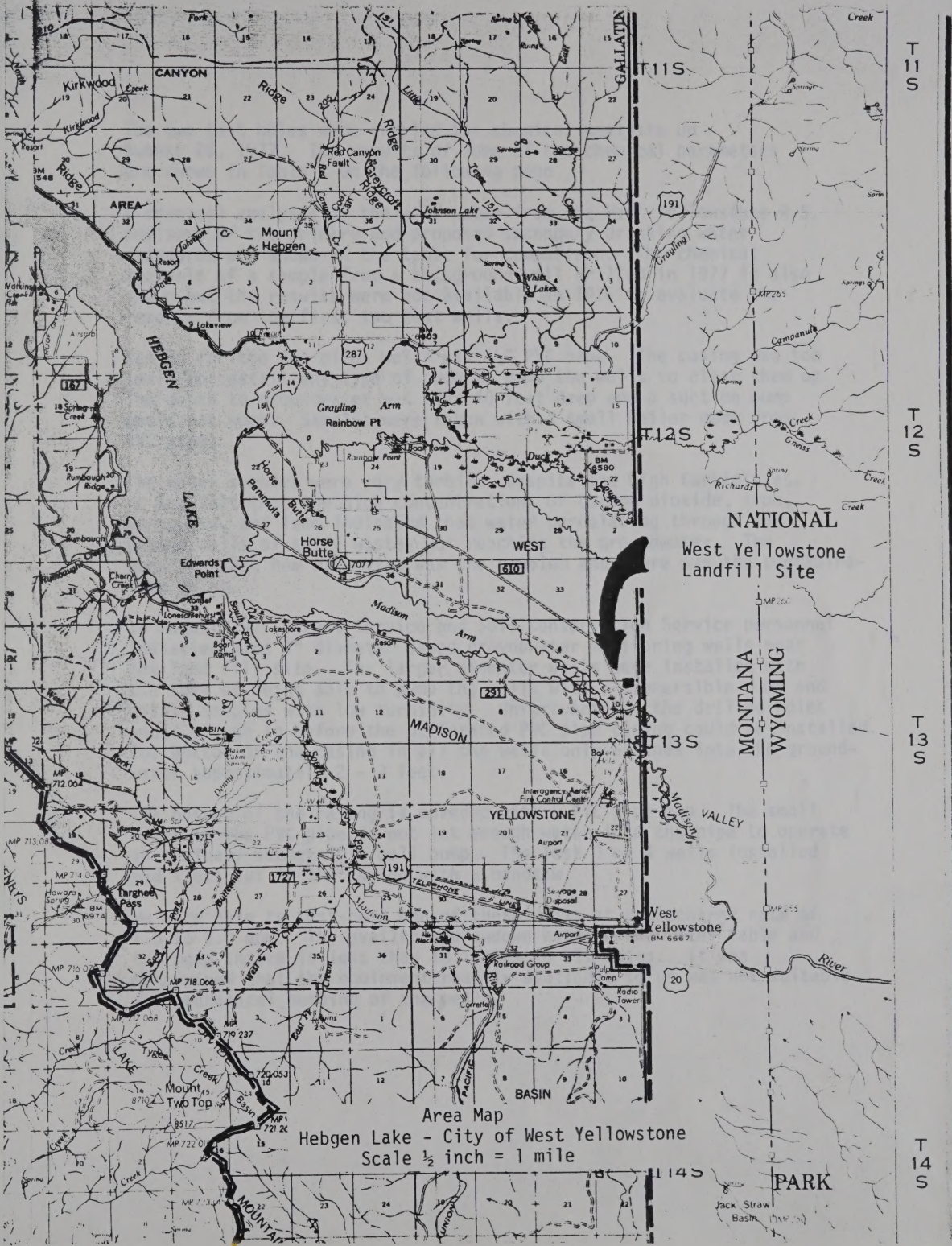
The West Yellowstone landfill is located on Forest Service land. (See area map on next page.) A special use permit for the site was given to the City of West Yellowstone. The city, in turn, leased the site to a private contractor. The contractor collects solid waste from whoever wants to pay for the service. People who prefer to haul their own solid wastes pay a dumping fee at the landfill site. The fees are paid directly to the contractor.

The landfill was opened for use in 1971. Use at the site has increased in the last two years because Yellowstone National Park started using the site for disposal of its solid wastes generated during the summer season.

Operation of the landfill has been excellent considering the climatic conditions in the area. The Montana Solid Waste Management Bureau stated in a memo that the West Yellowstone Landfill is one of the best landfills in the state (based on operation and maintenance).

In 1976, the State of Montana initiated a request that all landfill sites be evaluated to insure that the sites comply with current siting requirements. The Gallatin County Commissioners contacted the Soil Conservation District for assistance in evaluating the landfills in Gallatin County.

On August 3, 1976, the Soil Conservation Service drilled two test holes to determine the depth to groundwater. A small diameter pipe was installed in each of the two test holes so samples could be withdrawn from the groundwater at a later date.


T11S
T12S
T13S
T14S
CANYON
AREA
Mount Hebgen
HEBGEN LAKE
Grayling Arm
Rainbow Pt
Horse Butte
Edwards Point
WEST YELLOWSTONE
West Yellowstone Landfill Site
NATIONAL
MADISON
YELLOWSTONE
Madison Valley
MONTANA
WYOMING
Targhee Pass
Mount Two Top
BASIN
PARK
Jack Straw Basin
Area Map
Hebgen Lake - City of West Yellowstone
Scale ½ inch = 1 mile

The two test holes were sampled for chemical analysis on August 26, 1977. The results of some of the chemical parameters are shown in Table 1 on the following page.

A chemical analysis of the well water from the West Yellowstone R.S. and some of the primary and proposed secondary drinking water standards are shown in the table for comparison. The chemical analysis of a sample from a background well drilled in 1977 is also shown but the results were not available in 1976 to evaluate the results from the first two test wells.

Casing for the two pilot wells was 1½" PVC pipe. The casing was too small to install any type of pump to pump the wells to clear them up. The depth to groundwater was over 40 feet deep and a suction pump would not work. Samples were taken with a small bailer made from PVC pipe.

The water samples were very turbid. Despite the high turbidities, it was felt that the high concentrations of carbon dioxide, iron, manganese, and lead indicated that water percolating through the buried cells of solid wastes was reaching the groundwater. The question was, how extensive was the problem and where was the contamination going.

In August 1977 Forest Service and Soil Conservation Service personnel installed nine 4" diameter cased groundwater monitoring wells near the land fill site. The larger diameter wells were installed with the idea of being able to pump the wells with a submersible pump and obtain samples with low turbidity. Unfortunately, the drilled holes would slough in before the perforated PVC pipe casing could be installed. The bottom of the casing in all the wells only extends into the groundwater approximately 2 - 3 feet.

The bottom of the casing is covered with a PVC pipe cap. The small holes in the PVC pipe do not let enough water into the pipe to operate an ordinary submersible well pump. The last 3 or 4 wells installed had slots cut in the casing with a handsaw.

We were able to test-pump one of these wells at a discharge rate of 1.5 to 2.0 gpm. The available drawdown between the water table and the pump intake is less than 18 inches in all cases. It was determined that the equipment readily available to us was not suitable for mechanical pumping of the wells.

TABLE I - TABULATION OF CHEMICAL

Analyses of Samples from Groundwater Monitoring
Wells near West Yellowstone Landfill - August 1976

Constituent	Primary and Proposed Secondary Drinking Water Regulations (SDWA)	West Yellowstone R. S. Well	Background Well in YNP	NW Pilot Monitoring Well	SW Pilot Monitoring Well
TDS (mg/L)	500	-	75	490	125
Carbon Dioxide (mg/L)	-	-	8	149	75
pH	6.5-8.5	7.6	6.9	6.6	6.3
Iron as Fe (mg/L)	0.3	< 0.01	1.18	171.2	94.4
Manganese as Mn (mg/L)	-	< 0.01	< 0.05	38.8	25.6
Lead as Pb (mg/L)	0.05	< 0.05	0.11	1.90	0.44
Chromium as Cr (mg/L)	0.05	< 0.05	< 0.01	0.05	< 0.05
Mercury as Hg (mg/L)	0.002	0.0008	< 0.001	0.0027	0.0027
Cadmium as Cd (mg/L)	0.010	< 0.005	< 0.01	0.012	0.015
2, 4-D	0.1	-	-	none	trace
BOD (mg/L) * Biochemical Oxygen Demand	-	-	-	12	17
COD (mg/L) * Chemical Oxygen Demand	-	-	-	176	148

* Tests performed by Bill Stone, MSU.

Figure 1 is a site map showing the location of the nine monitoring wells. The direction of groundwater movement in the area is shown based on the depth to groundwater at each well. One well is located inside Yellowstone National Park as a background well (well E). The purpose of the background well is to provide a measure of the water quality of the natural groundwater in the area.

In September 1977 all of the wells were sampled for chemcial analysis. A small seep located just above a small pond near the Madison River was also sampled (sampling point J on Figure 1). The majority of the samples were sent to Orlando Laboratories, Inc., in Orlando, Florida for analysis. Some check samples were also analyzed for a cross-section of chemical parameters with a Hach DR-EL/2 Engineer's Laboratory by Gordon Nicholson, a sanitary engineer with the Forest Service.

The origin of the water at the small seep at sampling point J is questionable. The pond surface elevation on the east side of Highway 191 is 0.37 feet above the pond surface elevation on the west side of the highway. The seep is located just above the water level of the west pond. It is impossible to say at this time if the seep is a result of groundwater moving from the direction of the landfill or water seeping under the roadfill from the upper pond.

RESULTS OF CHEMICAL ANALYSES

Copies of the original laboratory reports showing the results of all chemical analyses are included in the Appendix. A summary of chemical tests made with the Hach Engineer's Laboratory is also included in the Appendix.

The chemical analyses indicated that at least seven chemical parameters showed increased concentrations in the groundwater downstream from the landfill. The chemical results for the seven parameters are summarized in Table 2. A description of each parameter and its significance is given in the following paragraphs.

Total Dissolved Solids (TDS)

The total dissolved solids concentration is obtained by weighing the residue remaining after a known volume of water is evaporated. The amount of dissolved solids present in water is a consideration of its suitability for domestic use. The significance of the TDS results is that we see an increase from the 75 mg/l TDS at the background well up to 380 mg/l at well D.

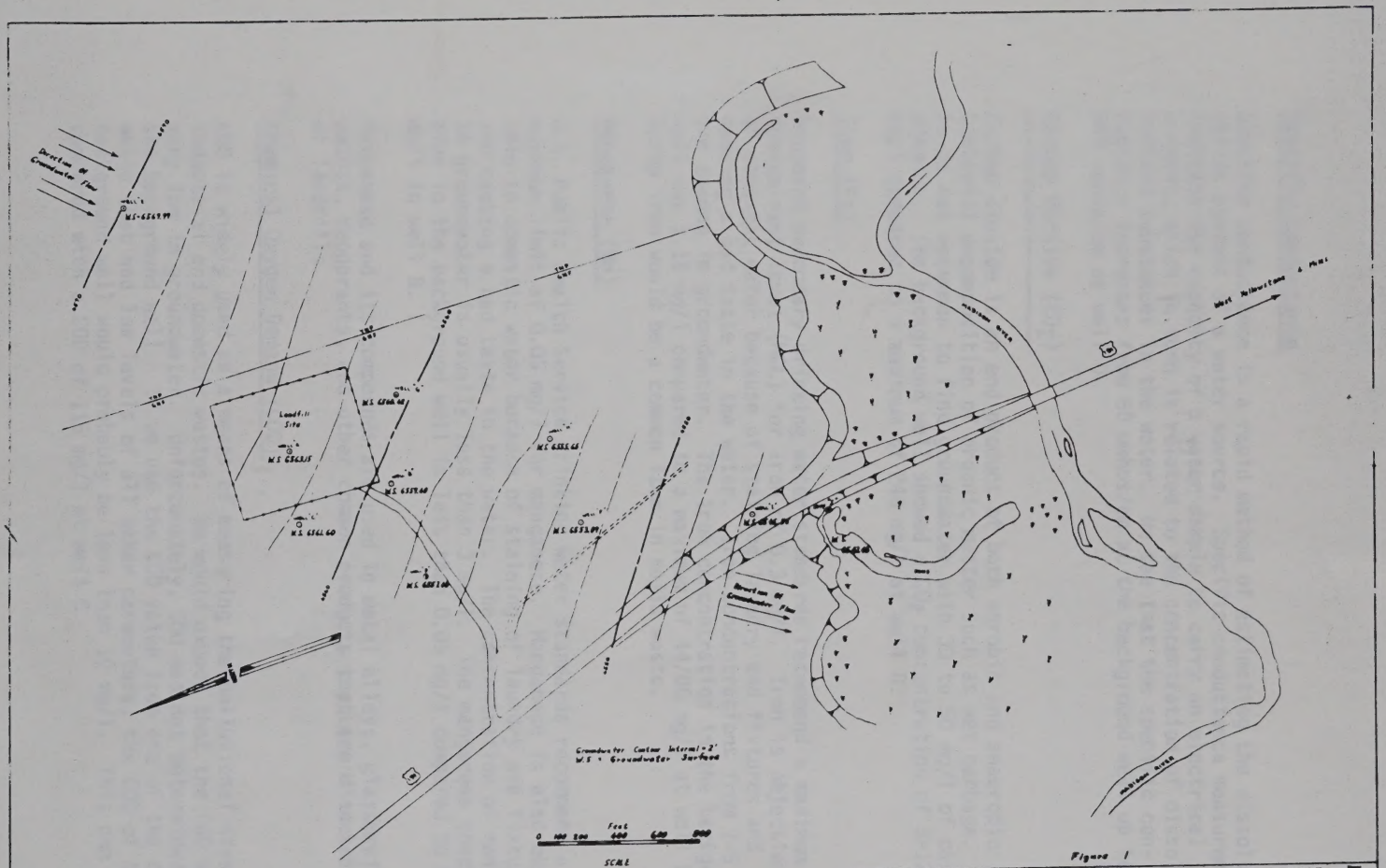


Figure 1

Designed By	Forest Engr. Number	WEST YELLOWSTONE SANITARY LANDFILL	U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE NORTHERN REGION
Drawn By	R.D. Thrasher	GROUNDWATER CONTOUR ELEVATIONS AS OF SEPT., 1977	Sheet 6
Checked By	R.D. Thrasher Approved & Date		File No.
			Project No.

Specific Conductance

Specific conductance is a rapid method of estimating the dissolved solids content of a water source. Specific conductance measurements indicate the capacity of a water sample to carry an electrical current, which in turn is related to the concentration of dissolved ionized substances in the water. We see that the specific conductance increases from 60 umhos/cm at the background well up to 440 umhos/cm at well D.

Carbon Dioxide (CO_2)

Carbon dioxide is an end product of both aerobic and anaerobic bacterial decomposition of organic matter such as wet garbage. It is not uncommon to find groundwater with 30 to 50 mg/l of carbon dioxide. The background well showed a CO_2 concentration of 8-12 mg/l compared to a maximum of 240 mg/l at well D.

Iron (Fe)

Proposed secondary drinking water standards recommend a maximum contaminant level (MCL) for iron of 0.3 mg/l. Iron is objectionable in domestic water because of staining laundry and fixtures and causing a bad taste in the water. Iron concentrations from 1-5 mg/l are common in groundwater. The iron concentration in the background well was 1.18 mg/l compared to a maximum of 44/06 mg/l at well D. Scrap iron would be a common item in solid waste.

Manganese (Mn)

U.S. Public Health Service drinking water standards recommend a maximum limit of 0.05 mg/l for manganese. Manganese is also objectionable in domestic water because of staining of laundry and fixtures and causing a bad taste in the water. The concentration of manganese in groundwater is usually less than 3 mg/l. The manganese concentration in the background well is less than 0.05 mg/l compared to 68.8 mg/l in well B.

Manganese and its compounds are used in metal alloys, glassmaking, paints, deodorants, and other common products that are disposed of at landfills.

Chemical Oxygen Demand (COD)

COD is widely used as a means of measuring the pollutional strength of industrial and domestic wastes. We would expect that the COD would be very low in groundwater. Unfortunately, COD was not determined for the background well. If we use the COD value from one of the other wells that had low levels of all other parameters, the COD of the background well would probably be less than 10 mg/l. This can be compared with a COD of 116 mg/l at well C.

Specific Conductance

Specific conductance is a rapid method of estimating the dissolved solids content of a water source. Specific conductance measurements indicate the capacity of a water sample to carry an electrical current, which in turn is related to the concentration of dissolved, ionized substances in the water. We see that the specific conductance increases from 80 umho/cm at the background well up to 440 umho/cm at well D.

Carbon Dioxide (CO_2)

Carbon dioxide is an end product of both aerobic and anaerobic bacterial decomposition of organic matter such as wet garbage. It is not uncommon to find groundwater with 20 to 50 mg/l of carbon dioxide. The background well showed a CO_2 concentration of 8-12 mg/l compared to a maximum of 240 mg/l at well D.

Iron (Fe)

Presently secondary drinking water standards recommend a maximum contaminant level (MCL) for iron of 0.3 mg/l. Iron is objectionable in domestic water because of staining laundry and fixtures and causing a bad taste in the water. Iron concentrations from 1.5 mg/l are common in groundwater. The iron concentration in the background well was 1.18 mg/l compared to a maximum of 14.00 mg/l at well D. Scrap iron would be a common item in solid waste.

Manganese (Mn)

U.S. Public Health Service drinking water standards recommend a maximum limit of 0.05 mg/l for manganese. Manganese is also objectionable in domestic water because of staining of laundry and fixtures and causing a bad taste in the water. The concentration of manganese in groundwater is usually less than 1 mg/l. The manganese concentration in the background well is less than 0.05 mg/l compared to 0.5 mg/l in well D.

Manganese and its compounds are used to metal alloys, electronics, paints, deodorants, and other common products that are disposed of at landfills.

Chemical Oxygen Demand (COD)

COD is widely used as a means of measuring the pollutional strength of industrial and domestic wastes. We would expect that the COD would be very low in groundwater. Unfortunately, COD was not determined for the background well. If we use the COD value from one of the other wells (D), but low levels of all other parameters, the COD of the background well would probably be less than 10 mg/l. This can be compared with a COD of 114 mg/l at well D.

Lead (Pb)

Lead is a serious cumulative body poison. Natural waters seldom contain more than 0.02 mg/l although values as high as 0.40 mg/l have been reported. The lead concentration in the background well is 0.11 mg/l. This number is suspect because six of the other wells had lead concentrations of 0.04 mg/l or less. A lead concentration of 0.21 mg/l was measured in well D. Lead concentrations in the two pilot wells drilled in 1976 were 1.90 mg/l and 0.44 mg/l respectively.

The peak concentration of 5 out of 7 of the above constituents occurs at well D. Contour maps based on the concentrations of the seven parameters were made to visually show the levels of contamination near the landfill area. Figures 2 through 8 show the contour maps.

The contour maps show that additional monitoring wells located west of the landfill should have been installed to determine the western edge of the flume of contaminants. The contour lines indicating the contaminant levels northwest of wells C and D are shown as dashed lines because they are our "best guess" approximations at this time. We would expect that the groundwater quality outside the groundwater flume in the "shadow" of the landfill site would return to natural levels within a very short distance.

DISCUSSION AND GENERAL CONCLUSION

Figures 2 through 8 show that there is a large increase in the concentrations of the chemical parameters downstream from the landfill site. A safe conclusion to make is that leachate from the landfill is contaminating the upper portion of the groundwater. The groundwater elevations also show that the contaminated groundwater is moving towards the sloughs and backwaters along the Madison River.

We did not get the data necessary to prove or disprove that the contamination is reaching the surface water near the Madison River. The contour maps show that additional sampling wells located 1000 - 1500 feet west of wells D, F. I, and the sampling point at J would be desirable.

We can say that the contamination is probably moving as a slug towards the Madison River. This is evidenced by the fact that the peak chemical concentrations were about 800 feet downstream from the landfill site. These slugs are probably caused by snow melting in the spring and percolating down through the buried refuse.

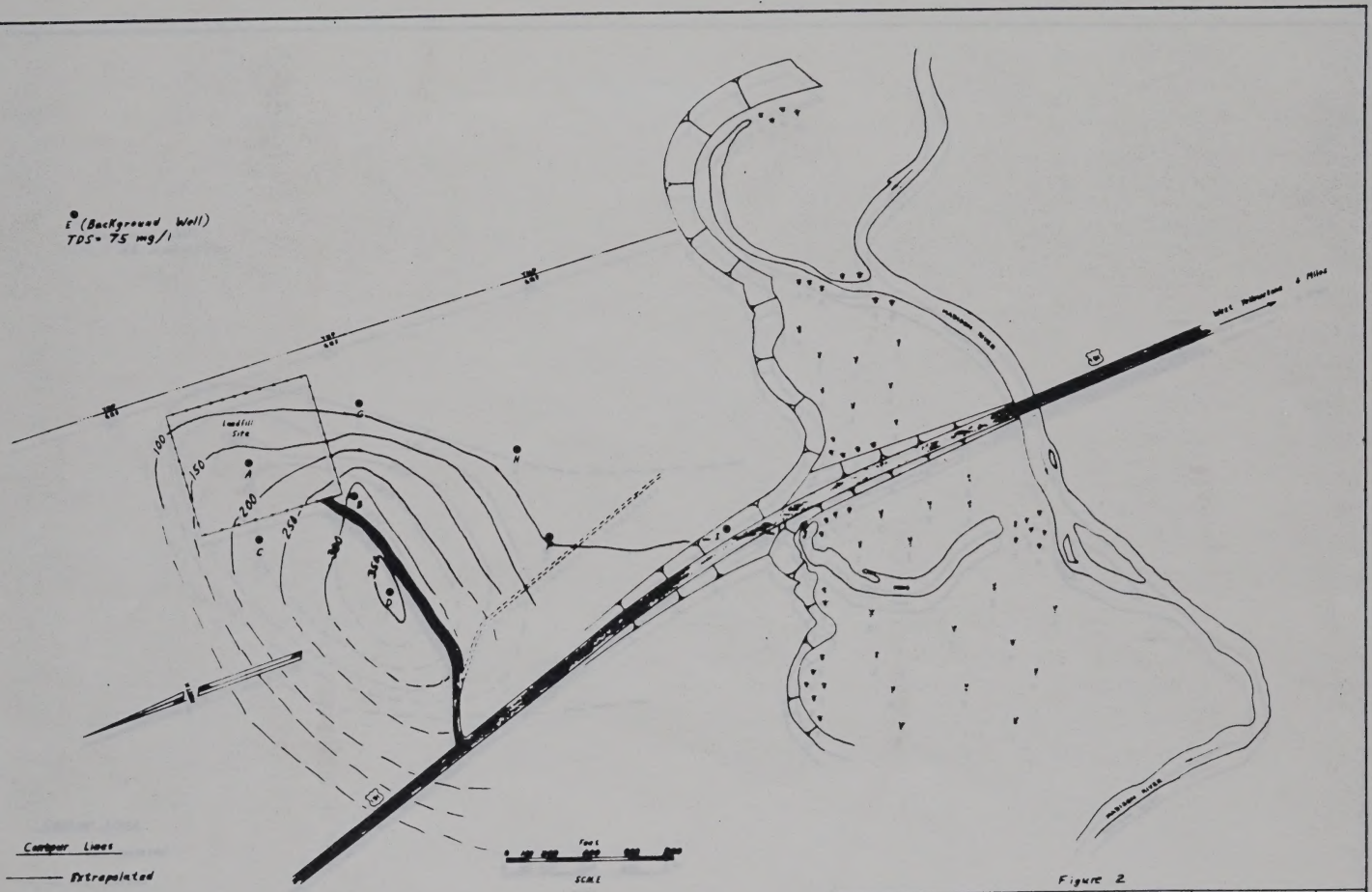


Figure 2

		TOTAL DISSOLVED SOLIDS (MG/L) IN UPPER GROUNDWATER NEAR W. YELLOWSTONE LANDFILL	U. S. DEPARTMENT OF AGRICULTURE FOREST SERVICE NORTHERN REGION	9

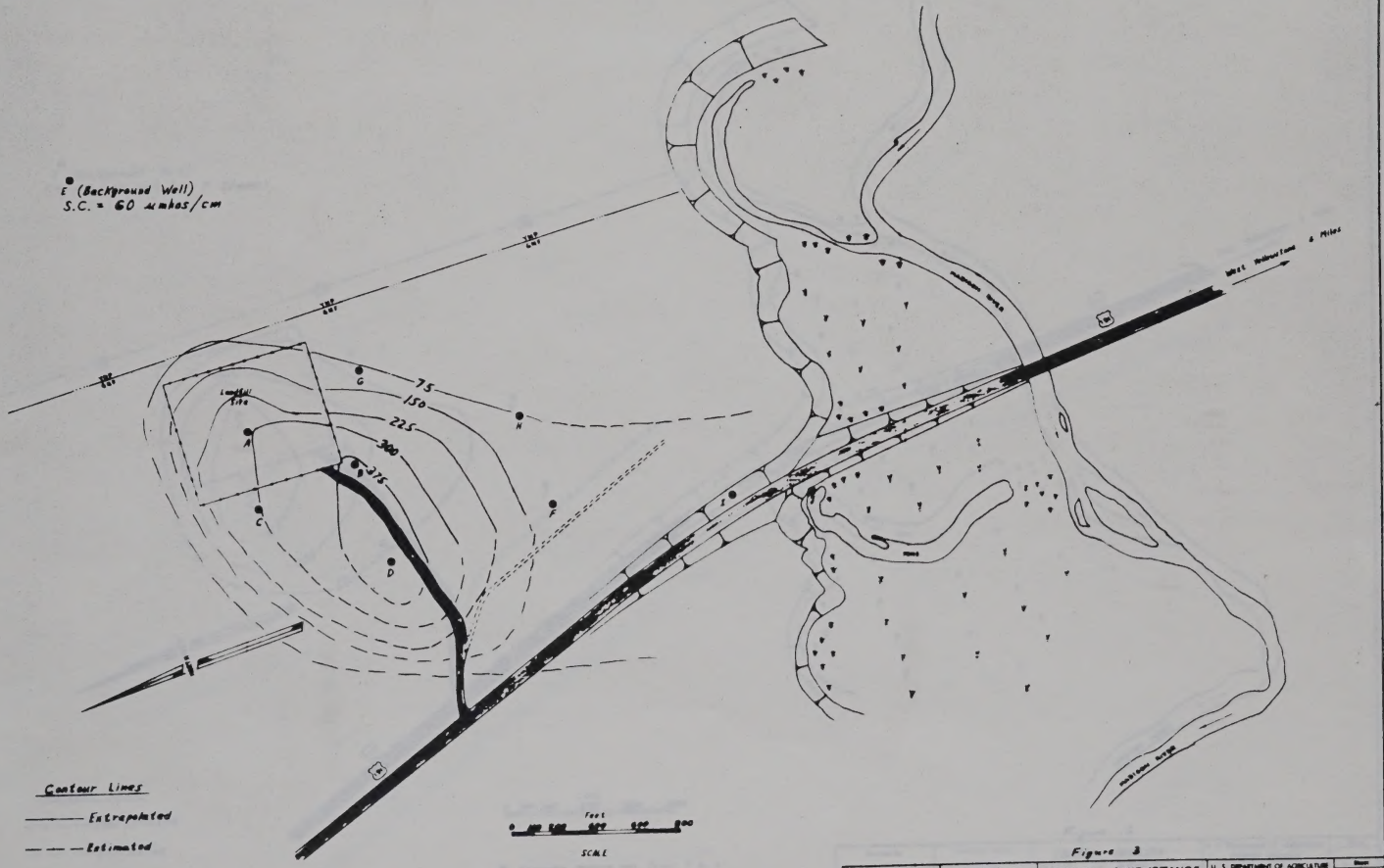

E (Background Well)
S.C. = 60 umhos/cm
75
150
225
300
375
Landfill Area
Contour Lines
Extrapolated
Estimated
Feet
SCALE
Groundwater Monitoring Well, Except J is A Surface Seep
SPECIFIC CONDUCTANCE (umhos/cm) IN UPPER GROUNDWATER NEAR W. YELLOWSTONE LANDFILL
U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
NORTHERN REGION
10

Figure 3

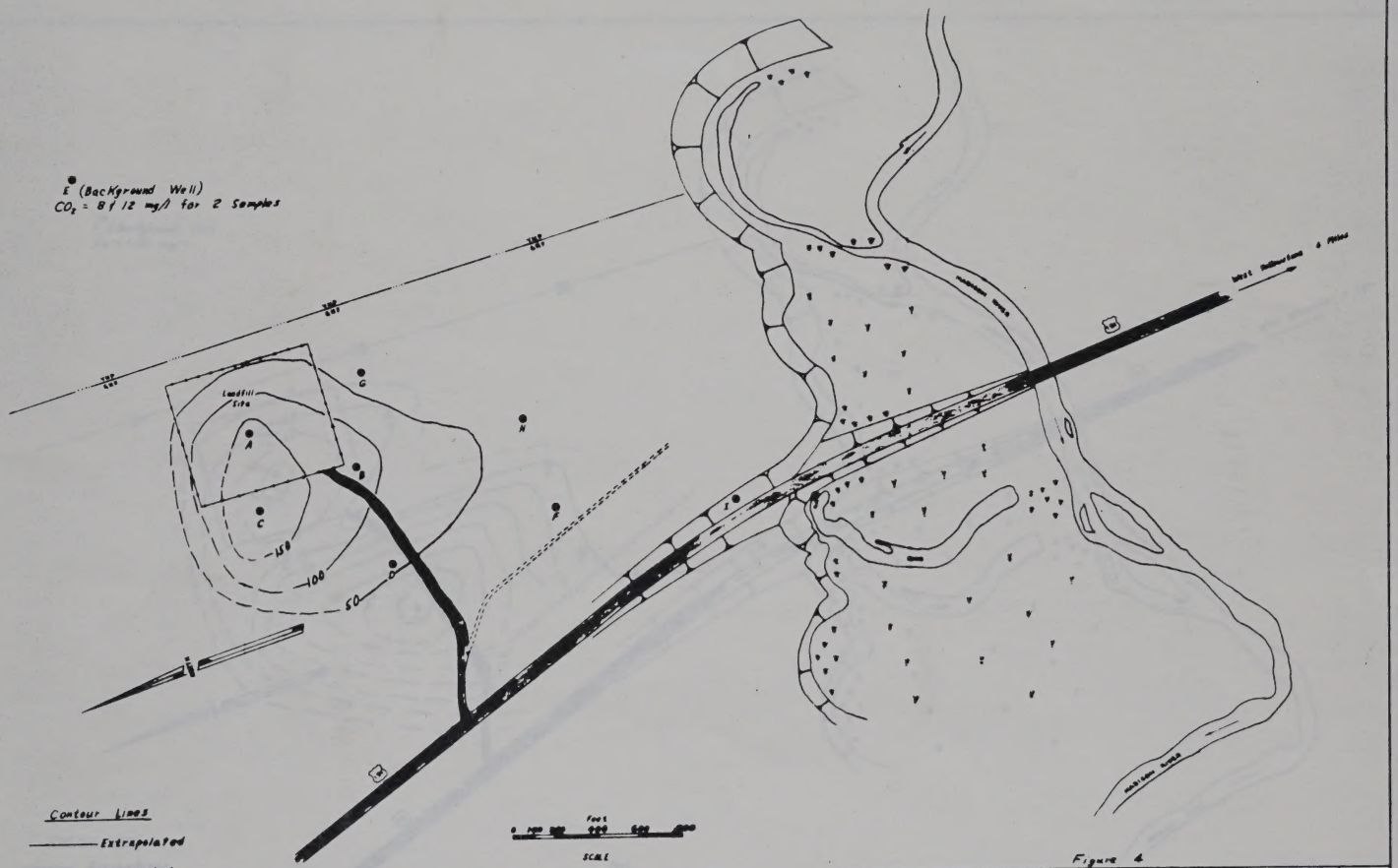
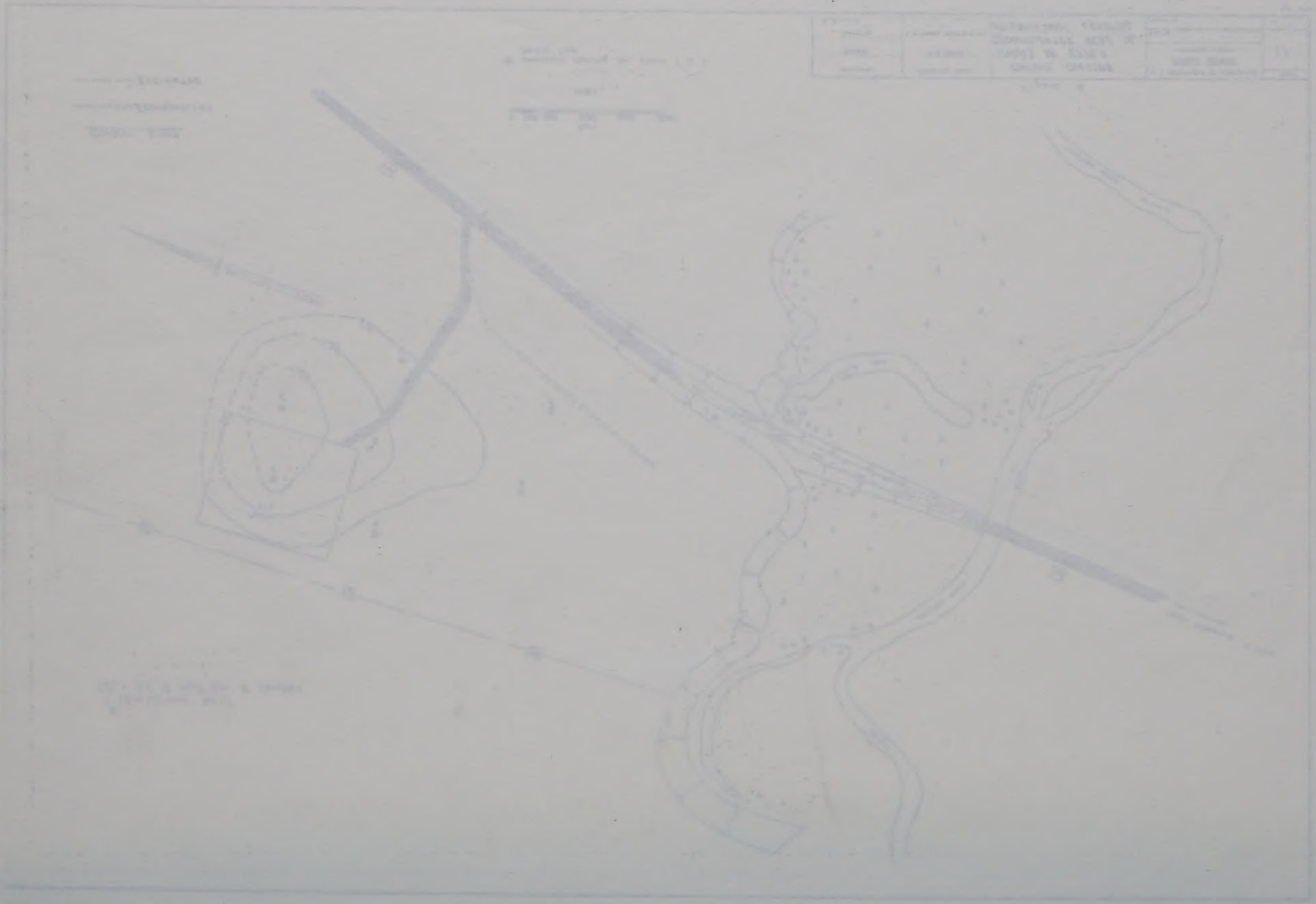


Figure 4

Designed By	Person Responsible	CARBON DIOXIDE (MG/L) IN UPPER GROUNDWATER NEAR W. YELLOWSTONE LANDFILL	U. S. DEPARTMENT OF AGRICULTURE FOREST SERVICE NORTHERN REGION	Sheet 11
Drawn By				
Checked By			File No.	
Approved By			Project No.	



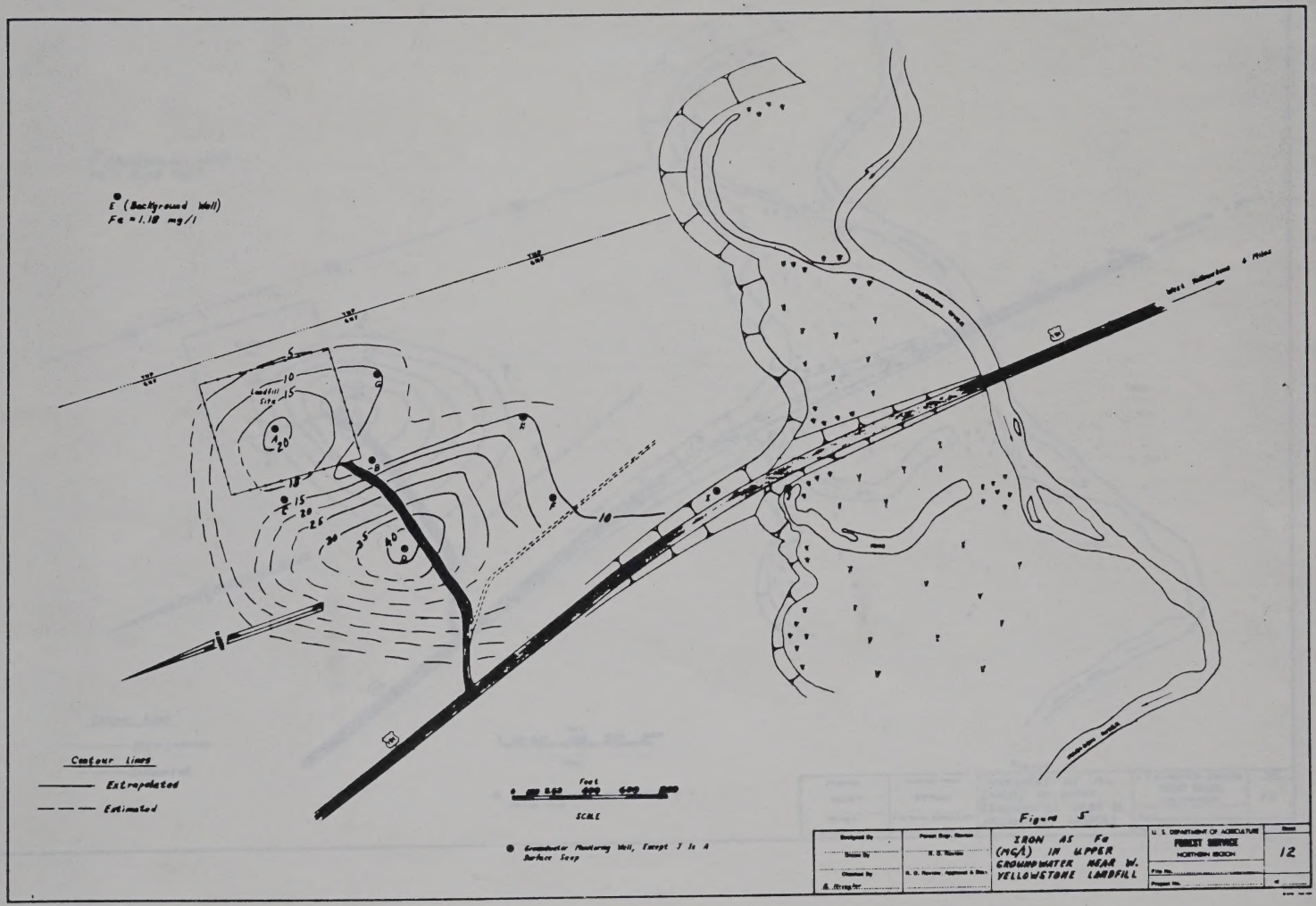


Figure 5

IRON AS Fe (mg/l) IN UPPER GROUNDWATER NEAR W. YELLOWSTONE LANDFILL

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
NORTHERN REGION

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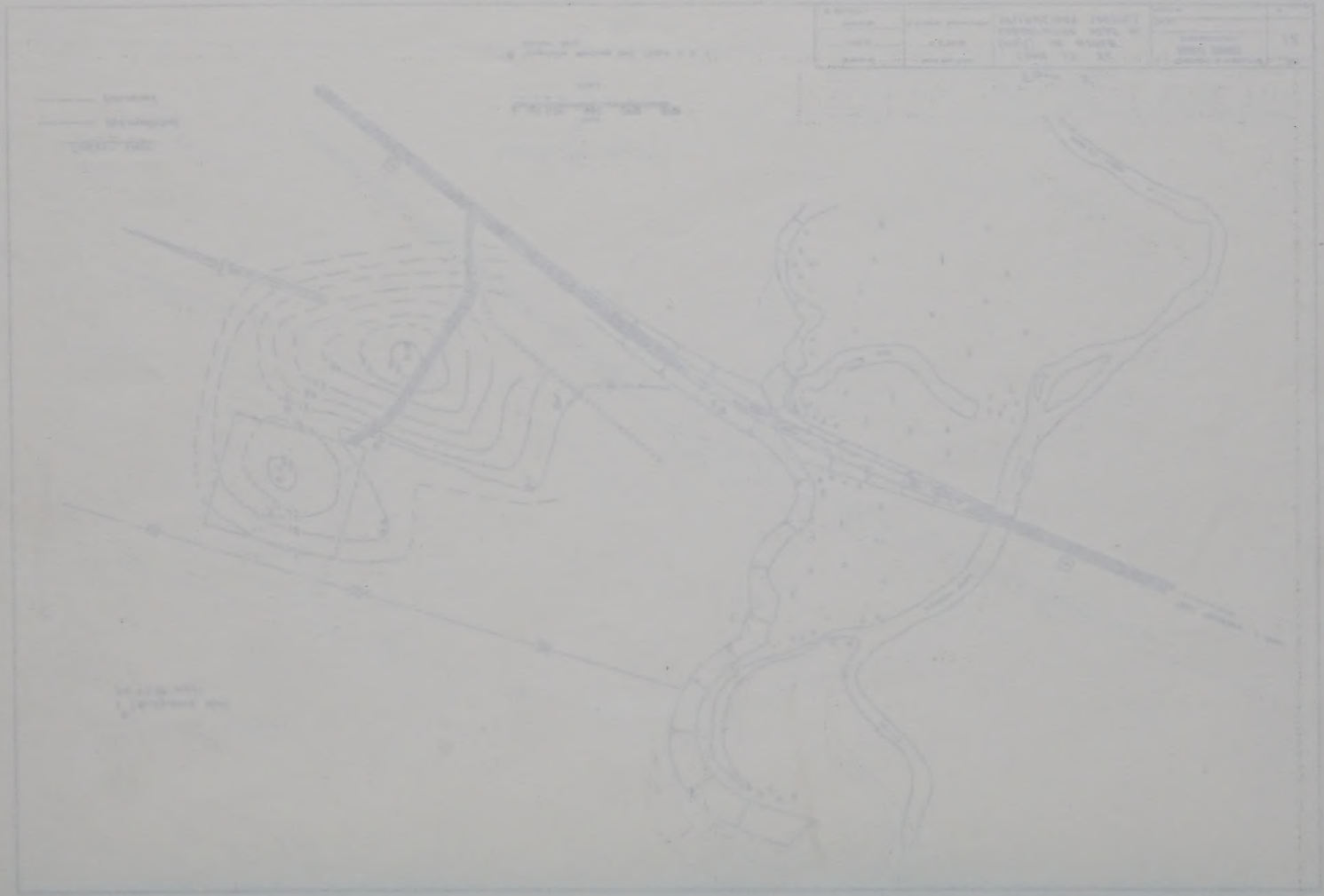


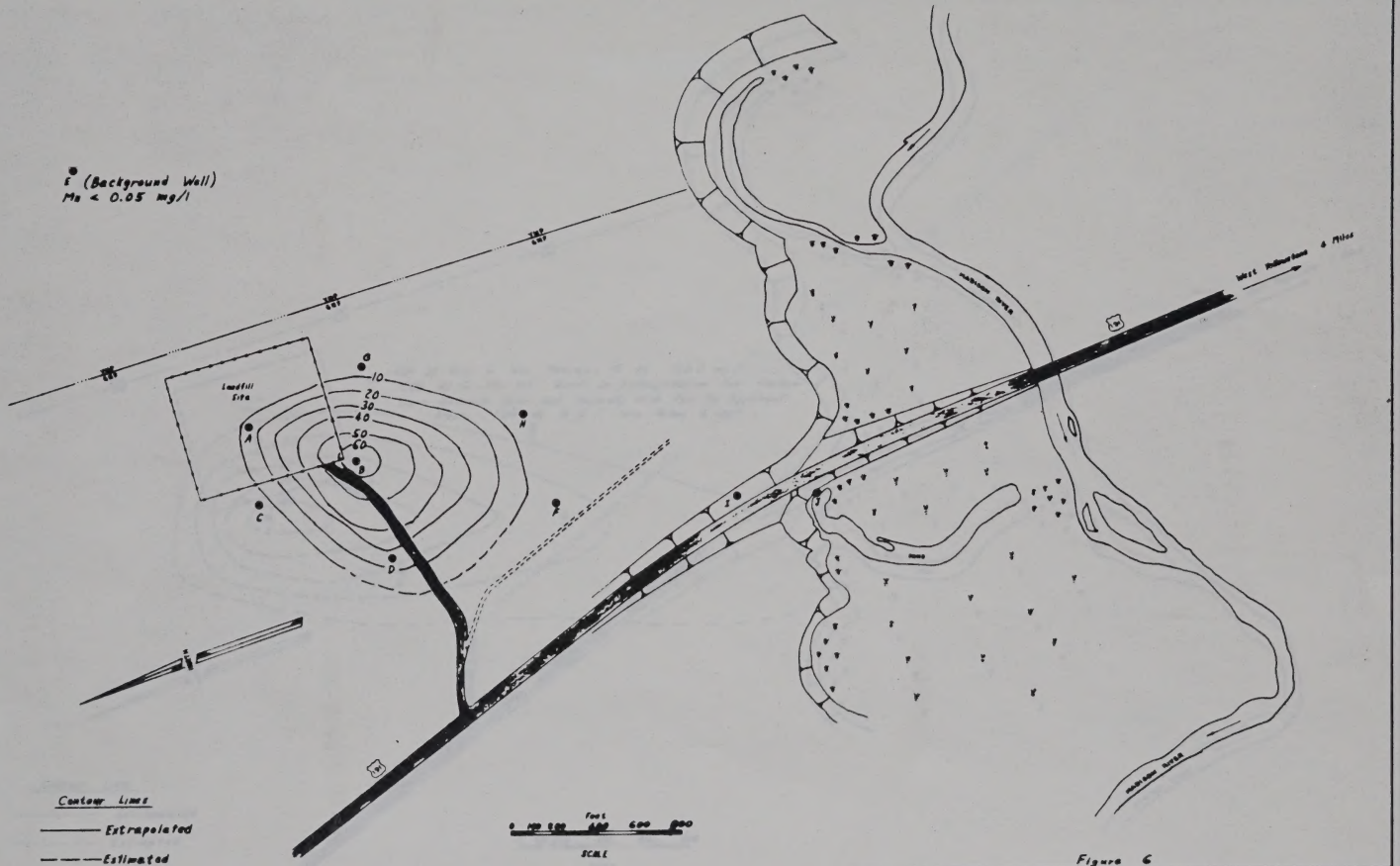


Figure 6

Designed By	Forest Engr. Number	MANGANESE AS Mn (MG/L) IN UPPER GROUNDWATER NEAR W. YELLOWSTONE LANDFILL	U. S. DEPARTMENT OF AGRICULTURE FOREST SERVICE NORTHERN REGION	Sheet 13
Drawn By	R. E. Thurber			
Checked By	R. D. Stevens Approved & Date		File No.	
R. Stevens			Project No.	

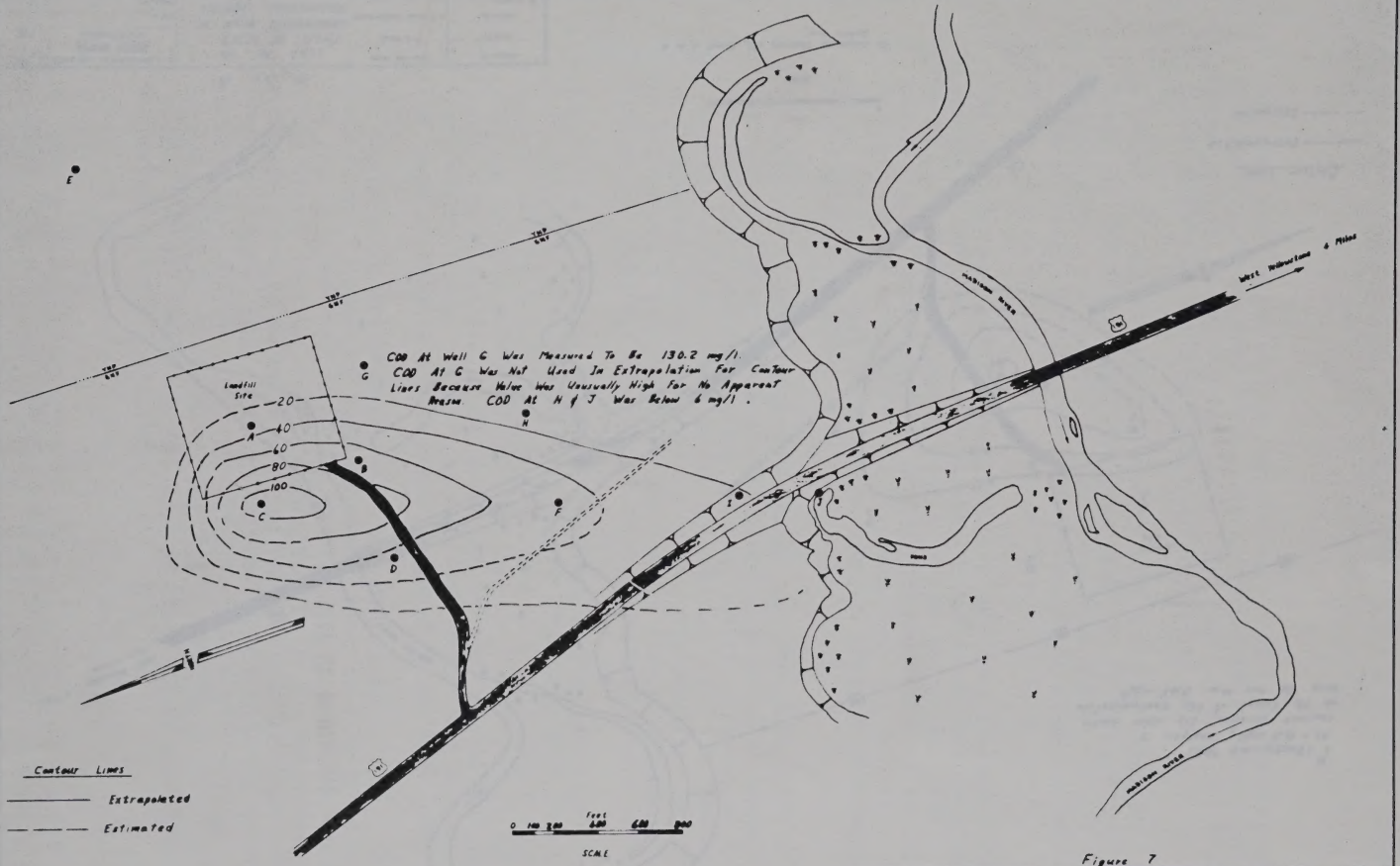
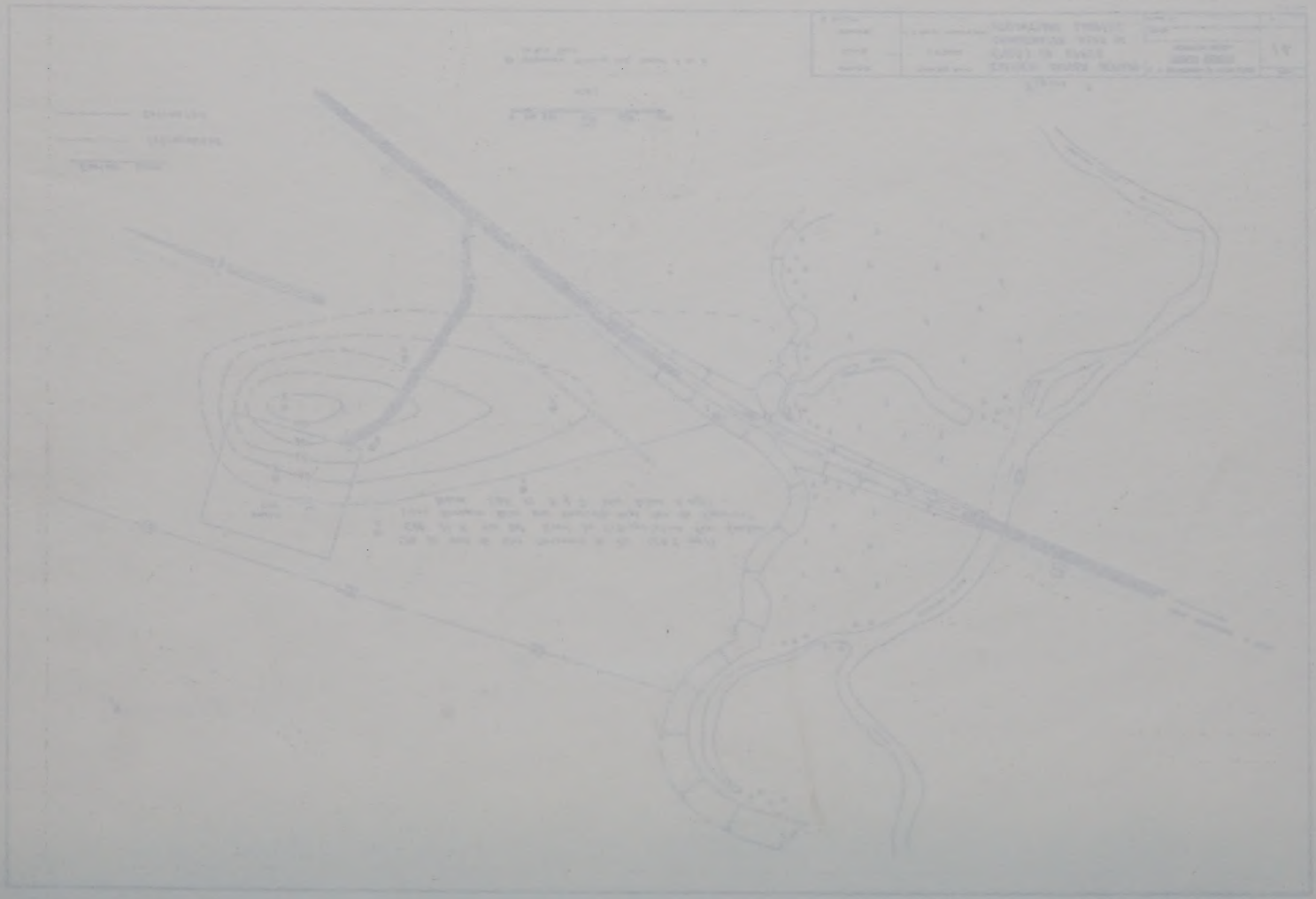


Figure 7

Designed By	Forrest Bray Reviewer	CHEMICAL OXYGEN DEMAND (MG/L) IN UPPER GROUNDWATER NEAR W. YELLOWSTONE LANDFILL	U. S. DEPARTMENT OF AGRICULTURE FOREST SERVICE NORTHERN REGION	Sheet 14
Drawn By	R. E. Reviewer			
Checked By	R. O. Reviewer Approved & Date		File No.	
R. Kriegler			Project No.	of



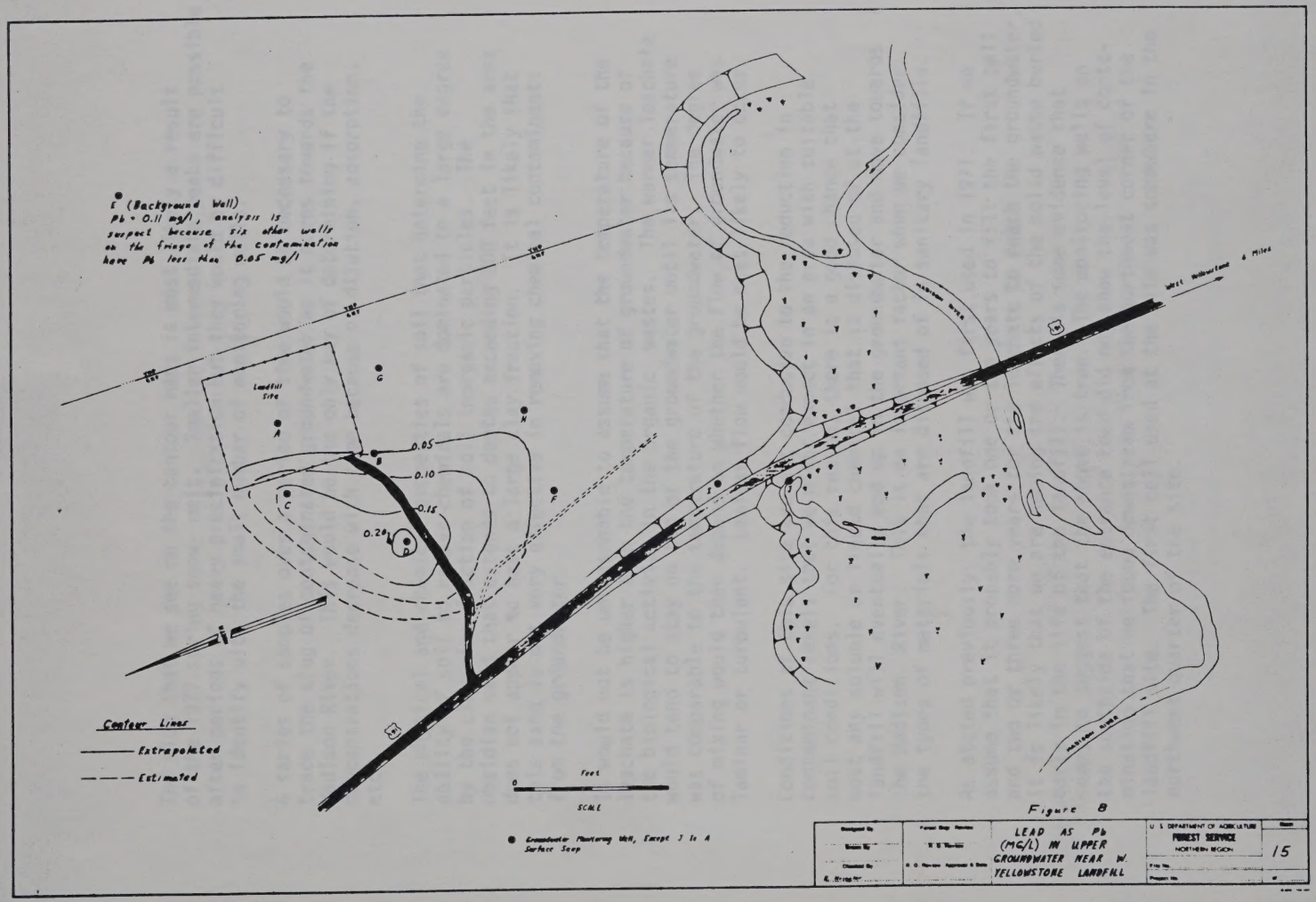

E (Background Well)
Pb = 0.11 mg/l, analysis is suspect because six other wells on the fringe of the contamination have Pb less than 0.05 mg/l
Landfill Site
A
B
C
D
E
F
G
H
0.05
0.10
0.15
0.20
Contour Lines
Extrapolated
Estimated
Feet
0
SCALE
Groundwater Monitoring Well, Except J is A Surface Seep
West Yellowstone 6 Miles
LEAD AS Pb (MG/L) IN UPPER GROUNDWATER NEAR W. YELLOWSTONE LANDFILL
U. S. DEPARTMENT OF AGRICULTURE
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Figure 8

The slug that we see on the contour maps is most likely a result of the 1977 spring snow- melt. Smaller intermediate peaks are possible after periods of heavy precipitation but they would be difficult to identify with the small number of monitoring wells.

A series of samples over a period of time would be necessary to trace the slug of contaminated groundwater as it moves towards the Madison River. This would be the only way of determining if the concentrations decrease with time because of dilution, adsorption, etc.

The physical and chemical properties of soil that determine the ability of soil to remove chemicals are dominated to a large degree by the clay-size fraction of soil inorganic particles. The obsidian sand that extends to depths exceeding 200 feet in the area does not appear to have a large clay fraction. It is likely that this sand is not very effective in removing chemical contaminants from the groundwater.

It would not be unreasonable to assume that the temperature of the leachate is higher than the temperature of groundwater because of the biological activity in the organic wastes. The warmer leachate would tend to stay on top of the groundwater until its temperature was comparable to the temperature of the groundwater. The degree of mixing would then depend on whether the flow of groundwater was laminar or turbulent. Laminar flow would be most likely to occur.

Conditions at this site are not conducive to the reduction in contaminant levels that we might expect in an area with suitable soil conditions. For this reason, there is a good chance that most any soluble or liquid chemical that is disposed of at the landfill will eventually end up in the groundwater and move towards the Madison River. This is an important factor when we consider the types of materials that are disposed of in sanitary landfills.

As stated previously, the landfill was first used in 1971. If we assume that it probably took one or two years to fill the first cell and two or three more years for the leachate to reach the groundwater, it is likely that we are seeing the effects of the solid waste buried early in the life of the landfill. There is some evidence that seems to suggest that the above is true. The monitoring wells on the southside of the entrance road did not show the level of contamination that we found downstream from the northwest corner of the landfill site. The first cell used at the site was somewhere in the northwest quarter of the site.

The implication of the previous paragraph is that we are likely to see an increase in the area contaminated with leachate for a period of time before we would see a gradual tapering off of the contaminant levels. This is likely even if the site was closed to dumping immediately.

A toxic blue-green algae bloom occurred in the Grayling Arm of Hebgen Lake during the summer of 1977. It is felt that a short discussion of what the chances are of a connection between the algae bloom and the landfill situation is warranted.

Nutrients are the most logical parameters to look at when considering the causes of an algae blooms. A one-year water quality study on Hebgen Lake completed in 1976 used the Hwy 191 bridge over the Madison River as a water sampling station.

The site was sampled three times for nitrates and phosphates. The report also quoted an annual discharge of 356,264 acre-feet per year for the Madison River.(unpublished EPA NLES Data)

Nitrates and phosphates were measured at several of the monitoring wells in 1977. The results are summarized below.

Well	$NO_3 - N_{(mg/l)}$	$PO_4 - P_{(mg/l)}$
B	1.33	1.30
C	-	9.00
D	-	4.65
E (Background Well)	0.47	4.37
J (Small seep)	-	0.28
Average Value	0.90	3.92

In order to make an estimate of the nutrients in the groundwater below the landfill, the following assumptions were made:

1. The width of the contaminated groundwater area is approximately 600 feet.

2. Mixing of the upper layer of the groundwater is not extensive and contaminants are confined to the upper two feet of the groundwater.

3. If we assume that the slug contamination shown on the contour maps is a result of the 1977 snowmelt, the groundwater is moving at an estimated average velocity of 2,800 feet per year.

4. Annual volume of water contaminated by the landfill is estimated to be 600 feet wide x 2 feet deep x 2800 feet long x 0.35 (% porosity of sand) = 8.8 million gallons per year.

The following is a summary of the estimated annual weight of nutrients carried by the Madison River and the groundwater contaminated by the landfill.

	NO_3 as N lbs/year	PO_4 as p lbs/year
Madison River		
356,264 acre-feet per year or 116 billion gallons per year Average (NO_3 as N) = 0.03 mg/l Average PO_4 as P = 0.014 mg/l	29,023	13,544
Groundwater Under Landfill		
8.8 Million Gallons Per Year Average NO_3 as N = 0.9 mg/l Average PO_4 as P = 3.9 mg/l	66	21
PO_4 as P measured at seep near pond (J) = 0.29 mg/l PO_4 as P shown as a range based on 0.29 mg/l to 3.9 mg/l		to 288

It can be seen that the amount of nutrients contributed by the landfill is likely to be a very small portion of the nutrients carried by the Madison River. When we consider that the background well had a phosphate concentration of 4.37 mg/l, it could be concluded that a large portion of the nutrients in the groundwater are constituents of the natural groundwater in the area.

SUMMARY

Many assumptions were made in writing this report. Hopefully, the majority of the assumptions are supported by the data collected in the field and reasonable engineering and geological interpretations.

It can be concluded that leachate from the landfill is reaching the groundwater. The leachate appears to be moving towards the back-waters and low lying areas near the Madison River. The sampling points near the river appear to be on the east edge of the flume of contaminants from the landfill. Additional sampling points or wells and monitoring would be needed to make positive statements about the contaminants reaching the surface water near the Madison River.

It is felt that the obsidian sand does not have the clay-size fraction of soil particles that is the dominant factor in the removal of chemicals in the groundwater. There is a good chance that a portion of the contaminants will reach the swampy areas along the Madison River.

Some heavy metals and complex organics tend to accumulate in animals. It would not be desirable from a public health, wildlife, and fisheries standpoint to allow these materisls to enter the Madison River in any appreciable quantity. Lead has already been found at very high levels (up to 1.90 mg/l) in the groundwater below the landfill.

The main purpose of this report is to inform the appropriate governmental bodies of what has happened to date concerning the monitoring program at the landfill site. It is suggested that copies of this report be submitted to appropriate regulatory agencies for their review and comment.

BIBLIOGRAPHY

Reference Works.

1. APHA, AWWA, & WPCF, Standard Methods for the Examination of Water and Wastewater, 13th Edition, American Public Health Association, Washington, D. C., 1971

2. Campbell, Michael D. and Lehr, Jay H., Water Well Technology, McGraw- Hill, New York, N.Y., 1974

3. Johnson Division, Universal Oil Products Co., Groundwater and Wells, Edward E. Johnson, Inc., St. Paul, Minnesota, 1966

4. Fair, Gordon M., Geyer, John C., and Okun, Daniel A., Water and Wastewater Engineering, Wiley, New York, N.Y., 1966

5. Sawyer, Clair N. and McCarty, Perry L., Chemistry for Sanitary Engineers, 2nd Edition, McGraw -Hill, New York, N.Y., 1967

6. U. S. Army Corps of Engineers, Wastewater Management by Disposal on Land. Special Report 171, Cold Regions Research and Engineering Laboratory, Hanover, New Hamphsire, 1972

7. Horpestad, Abe, Hebgen Lake Water Quality Study on the Gallatin National Forest, Montana Water Quality Bureau, 1976

BIBLIOGRAPHY

Reference Works.

1. APHA, AWWA, & WPCF. Standard Methods for the Examination of Water and Wastewater. 13th Edition. American Public Health Association, Washington, D. C., 1971.

2. Carpenell, Mitchell D. and Lehr, Jay H., Water Well Technology, McGraw-Hill, New York, N.Y., 1974.

3. Johnson Division, Universal Oil Products Co., Groundwater and Wells, Edward E. Johnson, Inc., St. Paul, Minnesota, 1966.

4. Fair, Gordon M., Geyer, John C., and Okun, Daniel A., Water and Wastewater Engineering, Wiley, New York, N.Y., 1968.

5. Sawyer, Clair B. and McCarty, Perry L., Chemistry for Sanitary Engineers, 2nd Edition, McGraw-Hill, New York, N.Y., 1967.

6. U. S. Army Corps of Engineers, Wastewater Management by Disposal on Land, Special Report 171, Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, 1972.

7. Norpestad, Abe, Hedgen Lake Water Quality Study on the Salmon National Forest, Montana Water Quality Bureau, 1975.

APPENDIX

STANDARD WATER ANALYSIS REPORT

Orlando Laboratories, Inc.

P. O. Box 8025A • Orlando, Florida 32806 • 305/843-1661

Report to: Gallatin National Forest

Appearance: Muddy

Date: 30 Aug. 76

Sampled by: Client

Report Number: 12173-1

Identification: SW Monitoring Well West Yellow-Stone Landfill, West Yellowstone Montana.

METHODS

This water was analyzed according to "Standard Methods for the Examination of Water and Wastewater," Latest Edition, APHA, AWWA and WPCF.

RESULTS

Determination	Data Significance	p.p.m.	Determination	Data Significance	p.p.m.
Total Dissolved Solids	x.	125	Total Hardness, as $CaCO_3$	x.	72
Phenolphthalein Alkalinity, as $CaCO_3$	x.	0	Calcium Hardness, as $CaCO_3$	x.	34
Total Alkalinity, as $CaCO_3$	x.	74	Magnesium Hardness, as $CaCO_3$	x.	38
Carbonate Alkalinity, as $CaCO_3$	x.	0	Calcium, as Ca	x.	14
Bicarbonate Alkalinity, as $CaCO_3$	x.	74	Magnesium, as Mg	.x	9.2
Carbonates, as CO_3	x.	0	Sodium, as Na	x.	7.8
Bicarbonates, as HCO_3	x.	90	Iron, as Fe	.x	94.4
Hydroxides, as OH	x.	0	Manganese, as Mn	.x	25.6
Carbon Dioxide, as CO_2	x.	75	Copper, as Cu	.x	<0.1
Chloride, as C1	x.	2	Silica, as SiO_2	x.	18
Sulfate, as SO_4	x.	10	Color, PCU	x.	0
Fluoride, as F	.x	0.1	Odor Threshold	x.	0
Phosphate, as PO_4	.x	1.1	Turbidity, NTU	x.	570
pH (Laboratory)	.x	6.3			
pHs	.x	8.6			
Stability Index	.x	10.9			
Saturation Index	.x	-2.3			

Signed: Donna Furbish

Chemist

(To convert ppm to grains per gallon, divide ppm by 17.1 – p.p.m. = mg/l)

STATE HEALTH DEPT. WATER QUALITY BUREAU HELENA, MONTANA 59601

STATE	MONTANA	COUNTY	GALLATIN
LAT.-LONG.		SAMPLE LOCATION	13S 5E CC
STATION CODE		ANALYSIS NUMBER	76W2083
DATE SAMPLED	08-26-76	DRAINAGE BASIN	041F -MADISON R.
TIME SAMPLED		WATER FLOW RATE	
METHOD SAMPLED	GRAB	FLOW MEASUREMENT METHOD	NOT MEASURED
SAMPLE SOURCE		ALTITUDE OF LAND SURFACE	6605. FT
WATER USE	UNUSED	TOTAL WELL DEPTH BELOW LS	
AQUIFER(S)		SWL ABOVE(+) OR BELOW LS	
SAMPLED BY	USFS	SAMPLE DEPTH BELOW SURFACE	

SAMPLING SITE: WEST YELLOWSTONE LANDFILL MONITORING WELL

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)			BICARBONATE(HCO3)		
MAGNESIUM (MG)			CARBONATE (CO3)		
SODIUM (NA)			CHLORIDE (CL)		
POTASSIUM (K)			SULFATE (SO4)		
IRON (FE)			FLUORIDE (F)		
MANGANESE (MN)			PHOSPHATE(PO4 AS P)		
ALUMINUM (AL)			NO3+NO2(TOT AS N)		
SUM CATIONS	0.0	0.0	SUM ANIONS	0.0	0.000

LABORATORY PH		TOT HARDNESS(MG/L-CACO3)	
FIELD WATER TEMPERATURE (C)		TOT ALKALINITY(MG/L-CACO3)	
SUM-DISS. IONS MEAS.(MG/L)		LABORATORY TURBIDITY (JTU)	
LAB CONDUCTIVITY-UMHOS-25C		SODIUM ADSORPTION RATIO	

ADDITIONAL PARAMETERS

LEAD, TOTAL (MG/L AS PB)	.44	CADMIUM,TOT (MG/L AS CD)	.015
CHROMIUM,TOT(MG/L AS CR)	< 0.05	SELENIUM,TOT(MG/L AS SE)	< 0.001
MERCURY,TOT (MG/L AS HG)	.0027	BARIUM,TOTAL(MG/L AS BA)	.50
SILVER, TOT (MG/L AS AG)	< 0.05	ARSENIC,TOT (MG/L AS AS)	.021

REMARKS: RW WELL RESULTS TO H KRINGLER PO BOX 130 BOZEMAN MT 59715
NO BOTTLE FOR NO3AND FLOURIDE

EXPLANATION: MG/L=MILLIGRAMS PER LITER MEQ/L=MILLIEQUIVILENTS PER LITER
ALL CONSTITUENTS DISSOLVED (DISS) EXCEPT AS NOTED. TOT=TOTAL SUSP=SUSPENDED
(M)= MEASURED(R)=REPORTED (E)=ESTIMATED M=METERS TR=TOTAL RECOVERABLE

SAMPLE NO 702 SAMPLER HRK HANDLING 1000 ANALYST KK LAB WQBH
COMPLETED 10-25-76 COMPUTER RUN 12/03/76 DATA 0975/PROG 0876 FUND 0650

STND DEV. ION BALANCE 0.00	CA	MG	NA	K	CL	SO4	HCO3	CO3	NO3
SEGMENT MPDES	0.0	0.0	0.0	0.0	33.3	33.3	0.0	33.3	0.0

CALC. MEQ/L= INSUFFICIENT DATA

76W2083

Orlando Laboratories, Inc.

P. O. Box 8025A • Orlando, Florida 32806 • 305/843-1661

Gallatin National Forest
Attn: Mr. Harry Kringler
P.O. Box 130
Bozeman, MONTANA 59715

Report No: 12188
Date: 31 Aug. 76
Sampled by : Client

IDENTIFICATION:
SW. Monitoring Well
West Yellowstone Landfill
West Yellowstone, Montana.

RESULTS OF ANALYSIS	Sample
Endrin	<0.0002
Lindane	<0.004
Methoxchlor	<0.1
Toxaphene	<0.005
2,4-D	Trace
2,4,5-TP	<0.01

Results in mg/l

Respectfully submitted,

ORLANDO LABORATORIES, INC.

Gene Yeskina
Chemist

STANDARD WATER ANALYSIS REPORT

Orlando Laboratories, Inc.

P. O. Box 8025A • Orlando, Florida 32806 • 305/843-1661

to: Gallatin National Forest

Appearance: Muddy

30 Aug. 76

Sampled by: Client

umber: 12173-2

Identification: NW Monitoring Well West Yellow Stone Landfill, West Yellowstone Montana

METHODS

ter was analyzed according to "Standard Methods for the Examination of Water and Wastewater," Latest Edition, APHA, AWWA and WPCF.

RESULTS

nation	Data Significance	p.p.m.	Determination	Data Significance	p.p.m.
solved Solids	x.	490	Total Hardness, as $CaCO_3$	x.	320
phthalein Alkalinity, as $CaCO_3$	x.	0	Calcium Hardness, as $CaCO_3$	x.	160
alinity, as $CaCO_3$	x.	300	Magnesium Hardness, as $CaCO_3$	x.	160
te Alkalinity, as $CaCO_3$	x.	0	Calcium, as Ca	x.	64
ate Alkalinity, as $CaCO_3$	x.	300	Magnesium, as Mg	.x	39
tes, as CO_3	x.	0	Sodium, as Na	x.	20
nates, as HCO_3	x.	366	Iron, as Fe	.x	171.2
des, as OH	x.	0	Manganese, as Mn	.x	38.8
Dioxide, as CO_2	x.	149	Copper, as Cu	.x	<0.1
, as C1	x.	33	Silica, as SiO_2	x.	19
, as SO_4	x.	14	Color, PCU	x.	0
, as F	.x	0.5	Odor Threshold	x.	0
nate, as PO_4	.x	9.0	Turbidity, NTU	x.	1800
oratory)	.x	6.6			
	.x	7.3			
Index	.x	8.0			
tion Index	.x	-0.7			

Signed: Donna Furbish

Chemist

(To convert ppm to grains per gallon, divide ppm by 17.1 – p.p.m. = mg/l)

ATE HEALTH DEPT. WATER QUALITY BUREAU HELENA, MONTANA 59601

STATE	MONTANA	COUNTY	GALLATIN
LAT.-LONG.	444349N 111 6 9W	SAMPLE LOCATION	13S 5E 3 CC
STATION CODE		ANALYSIS NUMBER	76W2082
DATE SAMPLED	8-24-76	DRAINAGE BASIN	041F -MADISON R.
TIME SAMPLED		WATER FLOW RATE	
METHOD SAMPLED	GRAB	FLOW MEASUREMENT METHOD	NOT MEASURED
SAMPLE SOURCE	WELL	ALTITUDE OF LAND SURFACE	
WATER USE	UNUSED	TOTAL WELL DEPTH BELOW LS	
AQUIFER(S)		SWL ABOVE(+) OR BELOW LS	
SAMPLED BY	USFS	SAMPLE DEPTH BELOW SURFACE	

SAMPLING SITE: WEST YELLOWSTONE LANDFILL MOUITOKINE WELL

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)			BICARBONATE (HCO3)		
MAGNESIUM (MG)			CARBONATE (CO3)		
SODIUM (NA)			CHLORIDE (CL)		
POTASSIUM (K)			SULFATE (SO4)		
IRON (FE)			FLUORIDE (F)		
MANGANESE (MN)			PHOSPHATE(PO4 AS P)		
ALUMINUM (AL)			NO3+NO2(TOT AS N)		
SUM CATIONS	0.0	0.0	SUM ANIONS	0.0	0.000

LABORATORY PH	TOT HARDNESS(MG/L-CACO3)
FIELD WATER TEMPERATURE (C)	TOT ALKALINITY(MG/L-CACO3)
SUM-DISS. IONS MEAS.(MG/L)	LABORATORY TURBIDITY (JTU)
LAB CONDUCTIVITY-UMHOS-25C	SODIUM ADSORPTION RATIO

ADDITIONAL PARAMETERS

LEAD, TOTAL (MG/L AS PB)	1.9	CADMIUM,TOT (MG/L AS CD)	.012
CHROMIUM,TOT(MG/L AS CR)	.05	SELENIUM,TOT(MG/L AS SE)	< 0.001
MERCURY,TOT (MG/L AS HG)	.0027	BARIUM,TOTAL(MG/L AS BA)	.58
SILVER, TOT (MG/L AS AG)	< 0.05	ARSENIC,TOT (MG/L AS AS)	.032

REMARKS: MW WELL RESULTS TO H KRINGLER PO BOX 130 BOZEMAN MT 59715
PESTICIDE REPORT ATTACHED

EXPLANATION: MG/L=MILLIGRAMS PER LITER MEQ/L=MILLIEQUIVILENTS PER LITER
ALL CONSTITUENTS DISSOLVED (DISS) EXCEPT AS NOTED. TOT=TOTAL SUSP=SUSPENDED
(M)= MEASURED(R)=REPORTED (E)=ESTIMATED M=METERS TR=TOTAL RECOVERABLE

SAMPLE NO 701 SAMPLER MRK HANDLING 2000 ANALYST LAB LAB WQBH
COMPLETED 10-25-76 COMPUTER RUN 11/04/76 DATA 0975/PROG 0876 FUND 0650

IND DEV.	ION BALANCE 0.00	CA	MG	NA	K	CL	SO4	HCO3	CO3	NO3
EGMENT	MPDES	0.0	0.0	0.0	0.0	33.3	33.3	0.0	33.3	0.0

STANDARD WATER ANALYSIS REPORT

SEP 15 1977
GALLATIN NATIONAL FOREST
BOZEMAN, MONTANA

Orlando Laboratories, Inc.

P. O. Box 8008 • Orlando, Florida 32806 • 305/843-1661

ort to: Gallatin National Forest

e: 12 Sept. 77

ort Number: 13858-1

Appearance: Turbid

Sampled by: Client

Identification: Well B West Yellowstone Landfil

METHODS

water was analyzed according to "Standard Methods for the Examination of Water and Wastewater," Latest Edition, APHA, AWWA and WPCF.

RESULTS

rmination	Data Significance	mg/l
l Dissolved Solids	x.	330
nolphthalein Alkalinity, as $CaCO_3$	x.	0
l Alkalinity, as $CaCO_3$	x.	183
onate Alkalinity, as $CaCO_3$	x.	0
rbonate Alkalinity, as $CaCO_3$	x.	183
onates, as CO_3	x.	0
rbonates, as HCO_3	x.	223
roxides, as OH	x.	0
on Dioxide, as CO_2	x.	115
ride, as Cl	x.	8.0
ate, as SO_4	x.	7
ride, as F	.x	0.3
sphate, as PO_4	.x	1.30
(Laboratory)	.x	6.5
	x	7.8
ility Index	.x	9.1
ration Index	.x	-1.3

Determination	Data Significance	mg/l
Total Hardness, as $CaCO_3$	x.	180
Calcium Hardness, as $CaCO_3$	x.	84
Magnesium Hardness, as $CaCO_3$	x.	96
Calcium, as Ca	x.	34
Magnesium, as Mg	.x	23
Sodium, as Na	x.	9.0
Iron, as Fe	.x	7.5
Manganese, as Mn	.x	68.8
Copper, as Cu	.x	<0.1
Silica, as SiO_2	x.	60
Color, PCU	x.	10
Odor Threshold	x.	0
Turbidity, NTU	x.	300

Signed: Donna Furbish

Chemist

STANDARD WATER ANALYSIS REPORT

Orlando Laboratories, Inc.

P. O. Box 8008 • Orlando, Florida 32806 • 305/843-1661

Report to: Gallatin National Forest

Appearance: Turbid with Sediment

Date: 15 Sept. 77

Sampled by: Client

Report Number: 13883-1

Identification: Well D WYSLF

METHODS

This water was analyzed according to "Standard Methods for the Examination of Water and Wastewater," Latest Edition, APHA, AWWA and WPCF.

RESULTS

Determination	Data Significance	mg/l
otal Dissolved Solids	x.	380
henolphthalein Alkalinity, as $CaCO_3$	x.	0
otal Alkalinity, as $CaCO_3$	x.	270
arbonate Alkalinity, as $CaCO_3$	x.	0
icarbonate Alkalinity, as $CaCO_3$	x.	270
arbonates, as CO_3	x.	0
icarbonates, as HCO_3	x.	329
ydroxides, as OH	x.	0
arbon Dioxide, as CO_2	x.	27
hloride, as Cl	x.	6
ulfate, as SO_4	x.	1
luoride, as F	.x	0.28
hosphate, as PO_4	.x	4.65
H (Laboratory)	.x	7.3
Hs	.x	7.4
ability Index	.x	7.5
aturation Index	.x	-0.1

Determination	Data Significance	mg/l
Total Hardness, as $CaCO_3$	x.	324
Calcium Hardness, as $CaCO_3$	x.	150
Magnesium Hardness, as $CaCO_3$	x.	174
Calcium, as Ca	x.	60
Magnesium, as Mg	.x	42
Sodium, as Na	x.	10
Iron, as Fe	.x	1.15
Manganese, as Mn	.x	31
Copper, as Cu	.x	<0.1
Silica, as SiO_2	x.	44
Color, PCU	x.	1
Odor Threshold	x.	0
Turbidity, NTU	x.	47

Signed: Gene Weldon

Chemist

STANDARD WATER ANALYSIS REPORT

Orlando Laboratories, Inc.

P. O. Box 8008 • Orlando, Florida 32806 • 305/843-1661

eport to: Gallatin National Forest

Date: 15 Sept. 77

Report Number: 13883-2

Appearance: Very Turbid with Sediment

Sampled by: Client

Identification: Background Well Upstream, Location YNP
Well E

METHODS

This water was analyzed according to "Standard Methods for the Examination of Water and Wastewater," Latest Edition, APHA, AWWA and WPCF.

RESULTS

Determination	Data Significance	mg/l
Total Dissolved Solids	x.	75
henolphthalein Alkalinity, as $CaCO_3$	x.	0
Total Alkalinity, as $CaCO_3$	x.	30
rbonate Alkalinity, as $CaCO_3$	x.	0
Bicarbonate Alkalinity, as $CaCO_3$	x.	30
rbonates, as CO_3	x.	0
Bicarbonates, as HCO_3	x.	37
ydroxides, as OH	x.	0
Carbon Dioxide, as CO_2	x.	8
hloride, as Cl	x.	3
Sulfate, as SO_4	x.	1
uoride, as F	.x	0.36
Phosphate, as PO_4	.x	4.37
H (Laboratory)	.x	6.9
Hs	.x	9.1
ability Index	.x	11.3
turation Index	.x	-2.2

Determination	Data Significance	mg/l
Total Hardness, as $CaCO_3$	x.	24
Calcium Hardness, as $CaCO_3$	x.	18
Magnesium Hardness, as $CaCO_3$	x.	6
Calcium, as Ca	x.	7.2
Magnesium, as Mg	.x	1.5
Sodium, as Na	x.	3.4
Iron, as Fe	.x	1.18
Manganese, as Mn	.x	<0.05
Copper, as Cu	.x	<0.1
Silica, as SiO_2	x.	44
Color, PCU	x.	3
Odor Threshold	x.	0
Turbidity, NTU	x.	75

Signed: Gene Medina
Chemist

STANDARD WATER ANALYSIS REPORT

Orlando Laboratories, Inc.

P. O. Box 8008 • Orlando, Florida 32806 • 305/843-1661

eport to: Gallatin National Forest

Date: 12 Sept. 77

eport Number: 13858-2

Appearance: Turbid

Sampled by: Client

Identification: Pond below West Yellowstone Landfill (Sampling Point 5)

METHODS

This water was analyzed according to "Standard Methods for the Examination of Water and Wastewater," Latest Edition, APHA, AWWA and WPCF.

RESULTS

Determination	Data Significance	mg/l	Determination	Data Significance	mg/l
Total Dissolved Solids	x.	140	Total Hardness, as $CaCO_3$	x.	60
henolphthalein Alkalinity, as $CaCO_3$	x.	0	Calcium Hardness, as $CaCO_3$	x.	51
Total Alkalinity, as $CaCO_3$	x.	68	Magnesium Hardness, as $CaCO_3$	x.	9
arbonate Alkalinity, as $CaCO_3$	x.	0	Calcium, as Ca	x.	20
Bicarbonate Alkalinity, as $CaCO_3$	x.	68	Magnesium, as Mg	.x	2.2
arbonates, as CO_3	x.	0	Sodium, as Na	x.	6.6
Bicarbonates, as HCO_3	x.	83	Iron, as Fe	.x	0.36
ydroxides, as OH	x.	0	Manganese, as Mn	.x	0.10
Carbon Dioxide, as CO_2	x.	44	Copper, as Cu	.x	<0.1
hloride, as Cl	x.	2.4	Silica, as SiO_2	x.	38
Sulfate, as SO_4	x.	3	Color, PCU	x.	10
uoride, as F	.x	0.53	Odor Threshold	x.	0
Phosphate, as PO_4	.x	0.28	Turbidity, NTU	x.	31
H (Laboratory)	.x	6.5			
pHs	.x	8.5			
ability Index	.x	10.5			
Saturation Index	.x	-2.0			

Signed: Donna Sulick

Chemist

REPORT OF ANALYSIS

Orlando Laboratories, Inc.

P. O. Box 8025A • Orlando, Florida 32806 • 305/843-1661

TO:

Gallatin National Forest
Attn: Mr Harry Kringler
Box 130
Bozeman, MONTANA 59715

Report # 13896 -1
Date: 16 Sept 77
Sampled by: Client

IDENTIFICATION:

1 - Well 1 West Yellowstone Landfill 9-8-77 Well I
2 - Well A WYSLF 9-8-77
3 - Well C WYSLF 9-8-77

RESULTS OF ANALYSIS:	1	2	3
Total Dissolved Solids	80	175	230
pH	6.3	5.9	5.8
Iron, Fe	16.55	22.08	13.58
Manganese, Mn	2.44	16.24	3.4
Lead, Pb	0.02	0.02	0.17
Mercury, Hg	<0.001	<0.001	<0.001
Cadmium, Cd	<0.01	<0.01	<0.01
Chemical Oxygen Demand, COD	25.3	32.1	115.7
Arsenic As	<0.01	<0.01	<0.01

RESULTS EXPRESSED IN mg/l, UNLESS OTHERWISE DESIGNATED

Respectfully submitted,

ORLANDO LABORATORIES, INC.

Pat Evans

Chemist/Biologist/Bacteriologist

METHODS: "Standard Methods for the Examination of Water and Wastewater," Latest Edition, APHA, AWWA and WPCF

MONTANA STATE DEPARTMENT OF HEALTH AND ENVIRONMENTAL SCIENCES
SAMPLE COLLECTION ANALYTICAL REPORT FORM

1. Sample Number WQ 76-2082
2. Seal Number
3. Date Collected 24 Aug
4. Collected by H Kingslin
5. Date Forwarded to Lab 1 Sept

6. Sample Description:
(Product Name, Brand Codes, Etc.)
one gallon jug of water

7. Sample Source:
(Retailer, Address & Manufacturer - Distributor Address, and Where Obtained)
West Yellowstone Town well Monitoring Well Northwest Well

8. Analysis Desired: Chlorinated pesticides

DO NOT WRITE BELOW THIS LINE

1. Lab Analysis Number 76-816
2. Condition of Seal —
3. Date Received 1 Sept
4. How Received Hand

5. SUMMARY OF ANALYSIS:

none detected

1.5 l of the water was extracted according to EPA NAM Section 10, H ☑.

Gas Chromatography: 6 ft. column of 1.5% OV-17/1.95% QF-1 at 220°C electron capture detector carrier nitrogen at 60 cc/min oven at 225°C Varian 222 gas chromatograph

6. Reserve Sample:

7. Date Reported 10 Sept 76
8. Analyst(s) J J Lally

REPORT OF ANALYSIS

Orlando Laboratories, Inc.

P. O. Box 8025A • Orlando, Florida 32806 • 305/843-1661

TO:

Gallatin National Forest
Attn: Mr. Harry Kringler
Box 130
Bozeman, MONTANA 59715

Report # 13896-2
Date: 16 Sept. 77
Sampled by: Client

IDENTIFICATION:

4 - Well D WYSLF 9-8-77
5 - Pole Line Well WYSLF 9-8-77 Well F
6 - Interior Well WYSLF 9-8-77 Well H

RESULTS OF ANALYSIS:	4	5	6
Total Dissolved Solids	345	75	50
pH	7.1	6.0	6.1
Iron, Fe	44.06	9.44	9.93
Manganese, Mn	28.72	1.16	1.4
Lead, Pb	0.21	0.03	0.02
Mercury, Hg	<0.001	<0.001	<0.001
Cadmium, Cd	<0.01	<0.01	<0.01
Chemical Oxygen Demand, COD	56.4	44.7	5.83
Arsenic, As	0.03	<0.01	<0.01

RESULTS EXPRESSED IN mg/l, UNLESS OTHERWISE DESIGNATED

Respectfully submitted,

ORLANDO LABORATORIES, INC.

Chemist/Biologist/Bacteriologist

METHODS: "Standard Methods for the Examination of Water and Wastewater," Latest Edition, APHA, AWWA and WPCF and/or other EPA approved methods unless otherwise indicated.

REPORT OF ANALYSIS

Orlando Laboratories, Inc.

P. O. Box 8025A • Orlando, Florida 32806 • 305/843-1661

TO:

Gallatin National Forest
Attn: Mr. Harry Kringler
Box 130
Bozeman, MONTANA 59715

Report # 13896-3
Date: 16 Sept. 77
Sampled by: Client

IDENTIFICATION:

7 - Pond Below West Yellowstone Landfill 9-8-77 (Sampling Point J)
8 - Southside Well West Yellowstone Landfill 9-8-77, Well G

RESULTS OF ANALYSIS:	7	8
Total Dissolved Solids	95	60
pH	6.5	6.0
Iron, Fe	0.06	10.49
Manganese, Mn	<0.05	2.15
Lead, Pb	<0.01	<0.01
Mercury, Hg	<0.001	<0.001
Cadmium, Cd	<0.01	<0.01
Chemical Oxygen Demand, COD	2.92	130.2
Arsenic, As	<0.01	<0.01

RESULTS EXPRESSED IN mg/l, UNLESS OTHERWISE DESIGNATED

Respectfully submitted,

ORLANDO LABORATORIES, INC.

Pat Evans

Chemist/Biologist/Bacteriologist

METHODS: "Standard Methods for the Examination of Water and Wastewater," Latest Edition, APHA, AWWA and WPCF

ANALYSIS FOR NATIONAL INTERIM PRIMARY DRINKING WATER REGULATIONS

OCT 12 1977
GALLATIN NATIONAL FOREST
BOZEMAN, MONTANA

Orlando Laboratories, Inc.

P. O. Box 8025A • Orlando, Florida 32806 • 305/843-1661

TO:

Gallatin National Forest
Attn: Mr. Harry Kringler
P.O. Box 130
Bozeman, MONTANA 59715

Report # 13877
Date: 14 Sept. 77
Sampled by: Client

IDENTIFICATION:

Background Well In Yellowstone Park (Upstream) Well E

INORGANIC

CONTAMINANT	MCL*	FOUND	CONTAMINANT	MCL*	FOUND
Arsenic, As	0.05	0.02	Lead, Pb	0.05	0.11
Barium, Ba	1.0	<0.5	Mercury, Hg	0.002	<0.001
Cadmium, Cd	0.010	<0.01	Nitrate, NO_3-N	10	0.47
Chromium, Cr	0.05	<0.01	Selenium, Se	0.01	<0.01
Fluoride, F	1.4-2.4	0.6	Silver, Ag	0.05	<0.01

ORGANIC

Endrin	0.0002	<0.0002	Toxaphene	0.005	<0.001
Lindane	0.004	<0.001	2, 4-D	0.1	<0.01
Methoxychlor	0.1	<0.01	2, 4, 5-TP (Silvex)	0.01	<0.001

RESULTS EXPRESSED IN mg/l (ppm) UNLESS OTHERWISE DESIGNATED *MCL — MAXIMUM CONTAMINANT LEVELS

Respectfully submitted,

ORLANDO LABORATORIES, INC.

Gene Medina

Chemist/Biologist/Bacteriologist

This water sample (☐ does) (☑ does not) meet the Proposed National Interim Primary Drinking Water Standards.

Methods & Limits: In accordance with Federal Register - Vol. 40, No. 248, Part IV - Wednesday, December 24, 1975. U.S. Environmental Protection Agency, National Interim Primary Drinking Water Regulations.

METHODS: "Standard Methods for the Examination of Water and Wastewater," Latest Edition, APHA, AWWA and WPCF and/or other EPA approved methods unless otherwise designated

ANALYSIS FOR NATIONAL INTERIM PRIMARY DRINKING WATER REGULATIONS

Orlando Laboratories, Inc.

P. O. Box 8025A • Orlando, Florida 32806 • 305/843-1661

TO:

Gallatin National Forest
Attn: Mr. Harry Kringler
P.O. Box 130
Bozeman, MONTANA 59715

Report # 13891
Date: 16 Sept. 77
Sampled by: Client

IDENTIFICATION:

Well B West Yellowstone Landfill.

INORGANIC

CONTAMINANT	MCL*	FOUND	CONTAMINANT	MCL*	FOUND
Arsenic, As	0.05	0.01	Lead, Pb	0.05	0.04
Barium, Ba	1.0	1.0	Mercury, Hg	0.002	0.003
Cadmium, Cd	0.010	0.01	Nitrate, NO_3-N	10	1.33
Chromium, Cr	0.05	<0.01	Selenium, Se	0.01	<0.01
Fluoride, F	1.4-2.4	0.3	Silver, Ag	0.05	<0.01

ORGANIC

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Summary of Check Samples

Tested With Hach Engineers Laboratory

By Gordon Nicholson, USFS Sanitary Engineer *

Well ID	pH	Carbon Dioxide mg/l	Chloride mg/l	Specific Conductance umhos/cm
A	5.5	180	12.5	300
B (9-14-77)	6.5	120	10.0	290
C	5.0	140	25.0	300
C (9-14-77)	5.0	240	25.0	300
D	7.5	48	10.0	440
D (9-14-77	7.5+	60	10.0	440
E (9-14-77)	6.5	12	5.0	60
F	5.5	44	5.0	90
G	6.4	16	5.0	73
H	6.0	24	5.0	65
I	6.3	36	5.0	105
J	6.3	32	5.0	90 $\pm$

*Tests made September 9, 1977 unless otherwise noted.

Monitoring Well Elevations

Well ID	Elevation of Threaded Adapter on Top of Well Casing(feet above MSL	Depth to Ground-Water (feet)	Groundwater Elevation (feet above MSL
A	6610.70	47.55	6563.15
B	6610.45	51.05	6559.40
C	6609.50	47.90	6561.60
D	6609.55	52.12	6557.40
E	6611.87	41.88	6569.99
F	6613.51	60.42	6553.09
G	6612.02	51.60	6560.42
H	6611.17	55.52	6555.65
I	6591.13	45.58	6545.55
Surface Elevation of ponds east of Highway 191			6542.83
Surface Elevation of pond west of Highway 191			6542.46